KC•CORE

KANSAS CITY: CONNECTING OUR RIVERFRONT FOR EVERYONE (KC•CORE)

BENEFIT-COST ANALYSIS SUPPLEMENTARY DOCUMENTATION

FY2017 TIGER DISCRETIONARY GRANT PROGRAM

Prepared for:
Kansas City Area Transportation Authority / Port KC / Kansas City Streetcar Authority

OCTOBER 16, 2017

KC●CORE

EXECUTIVE SUMMARY

A benefit-cost analysis (BCA) was conducted for the KC●CORE Project submission to the U.S. Department of Transportation (U.S. DOT) as a requirement of a discretionary grant application for the TIGER 2017 program. The analysis was conducted in accordance with the benefit-cost methodology as outlined by U.S. DOT in the 2017 TIGER/INFRA Benefit-Cost Analysis Guidance. The period of analysis corresponds to 30 years and includes four years of construction and 26 years of benefits after operations begin in 2021.

The development and implementation of the initial 2.2-mile route was overseen by three partners: the Kansas City Streetcar Authority (KCSA), Kansas City Area Transportation Authority (KCATA), and the City of Kansas City, Missouri (KCMO). In 2016, the three initial project partners along with Port KC began to investigate the feasibility of extending the streetcar to the Riverfront and changing multi-modal connections and paths in the study area. In light of the proposed mixed-use development of 12 Riverfront parcels with completion dates ranging from 2018 through to 2029, this extension is intended to provide connectivity between the Riverfront and the downtown, stimulate economic activity at the Riverfront, and provide a non-vehicle travel option to access the "string" of downtown districts, as well as address parking demand and growing congestion.

COSTS

The capital cost for this Project is expected to be $32.0 million in undiscounted 2016 dollars through 2021. At a 7 percent real discount rate, these costs are $25.3 million. Operations and maintenance costs are projected to average $808,500 per year in the long term. Over the entire 30-year analysis period these costs accumulate to $20.7 million in undiscounted 2016 dollars, or $7.1 million when discounted at 7 percent. These costs are reflected in Table ES-1 below.

TABLE ES-1: Project Costs by Funding Source, in Undiscounted Millions of 2016 Dollars

Variable	Undiscounted Value	Discounted Value (7% Discount Rate)	Discounted Value (3% Discount Rate)
Construction Start	2018	2018	2018
Construction End	May 2021	May 2021	May 2021
Construction Duration	4 years	4 years	4 years
Project Opening	June 2021	June 2021	June 2021
Capital Cost	$32.0	$25.3	$28.9
O&M Cost	$ 20.7	$7.1	$12.6

The Project is expected to be financed by the sale/lease of (a) Port-KC owned land to private developers, (b) public-private mortgage of future developable parcels, (c) sale/lease of Port KC owned future developed parcels, and (d) development related funds controlled by Port KC.

BENEFITS

In 2016 dollars, the Project is expected to generate $50.0 million in discounted benefits using a 7 percent discount rate. These benefits are attributed to the reduction in vehicle miles travelled (VMT) and passenger hours travelled (PHT) that the streetcar will produce for new users from the Riverfront development, as well as existing users. This leads to an overall project Net Present Value (NPV) of $17.6 million and a Benefit Cost Ratio (BCR) of 1.54. At a 3 percent discount rate, the overall project NPV is expected to be $58.5 million and a BCR of 2.41.

The overall Project impacts can be seen in Table ES-2, which shows the magnitude of change and direction of the various impact categories.

Table ES-2: Project Impacts for the KC●CORE Project, Cumulative 2017-2046

Category	Unit	Quantity	Direction
Vehicle-Miles Traveled	VMT	352,978,095.30	▼
Vehicle-Hours Traveled	VHT	866,427.73	▼
Fuel Consumed	gallons	10,847,404.84	▼
CO_2 Emissions	tons	85,105.14	▼
NO_X Emissions	tons	11.28	▼
PM^{10}	tons	0.99	▼
SO_X	tons	1.24	▼
VOC	tons	22.88	▼

Source: WSP, 2017

In addition to the monetized benefits presented in Table ES-2, the Project would create the following qualitative benefits:

COMMUNITY DEVELOPMENT (LAND VALUE UPLIFT) POTENTIAL

The Berkley Riverfront Development Master Planned Development (MPD) outlines two density scenarios contingent upon the construction of the streetcar extension. With the streetcar extension, the developable parcels will reduce the amount of parking available to create additional residential square-footage. Without the streetcar extension, the development must consider additional parking for resident commuting purposes.

SAFETY

Safety benefits are anticipated from the streetcar extension due to the reduction in VMTs that are expected. Additionally, the new pedestrian and bicycle facility allows for safer, non-vehicular journeys to and from the Riverfront.

The overall project benefits over the analysis period is presented in Table ES-3 below.

Table ES-3: Project Benefits by Long-Term Outcome Category

Long-Term Outcome	Benefit (Disbenefit) Category	Monetized @ 7% Discount Rate	Monetized @ 3% Discount Rate
Quality of Life / Livability	Health Benefits	$100,000	$190,000
	Commuter Mobility Benefits	$400,000	$775,000
	Recreational Benefits	$5,000	$9,000
	Reduced Noise	$120,000	$245,000
	Community Development	Qualitative benefit	
Economic Competitiveness	Travel Time Savings	$4,250,000	$8,630,000
	Vehicle Operating Costs	$30,330,000	$61,330,000
	Fuel Savings	$9,460,000	$18,920,000
Safety	Reduced Incidents	Qualitative benefit	
State of Good Repair	Reduced Road Damage	$120,000	$245,000
	Residual Value	$2,020,000	$6,340,000
Environmental Sustainability	Reduced Emissions	$3,160,000	$3,315,000

EXECUTIVE SUMMARY 2
LIST OF TABLES 6
1 INTRODUCTION 7
1.1 BCA Framework 7
1.2 PRISM 8
1.3 Report Contents 8
2 PROJECT OVERVIEW 8
2.1 Description 8
2.2 General Assumptions 9
2.2.1 Basis of Economic Benefits 9
2.2.2 Discounting and Real Dollar Valuations 9
2.2.3 Evaluation Period 10
2.2.4 Ridership Estimates and Projection Sources 10
2.2.5 Benefit-Cost Evaluation Measures 11
2.3 No Build Case and Build Case 11
2.4 Project Costs 11
2.4.1 Capital Costs 11
2.4.2 Operations and Maintenance Costs 12
3 DEMAND PROJECTIONS AND ASSOCIATED SAVINGS 12
3.1.1 Induced Streetcar Trips 13
3.1.2 Existing Streetcar Trips 15
3.1.3 Total PHT and VMT Savings 16
3.2 Streetcar Capacity Constraints 16
4 PROJECT BENEFITS 17
4.1 Quality of Life / Livability 20
4.2 Economic Competitiveness 21
4.2.1 Travel Time Savings 21
4.2.2 Operating Cost Savings 22
4.3 Safety 22
4.4 State of Good Repair and Residual Value 23
4.5 Environmental Sustainability 23
5 SUMMARY OF RESULTS 24
5.1 Evaluation Measures 24
5.2 BCA Results 24
5.3 Sensitivity Testing 25

KC CORE

LIST OF TABLES

Table 1: Project Schedule and Costs, Millions of 2016 Dollars 12
Table 2: PHT and VMT Assumptions and Inputs (Induced Trips) 14
Table 3: Boarding and Alighting Distribution 15
Table 4: PHT and VMT Assumptions and Inputs (Existing Trips) 16
Table 5: Total No Build and Build PHT and VMT Savings 16
Table 6: Project Benefits by Long-Term Outcome Category 19
Table 7: Quality of Life / Livability Estimation of Benefits 20
Table 8: Quality of Life / Livability Assumptions and Sources 20
Table 9: Economic Competitiveness Estimation of Benefits 21
Table 10: Travel Time Savings Assumptions and Sources 21
Table 11: Operating Cost Savings Assumptions and Sources 22
Table 12: State of Good Repair Estimation of Benefits 23
Table 13: State of Good Repair Benefits Assumptions and Sources 23
Table 14: Environmental Sustainability Estimation of Benefits 23
Table 15: Environmental Sustainability Benefits Assumptions and Sources 24
Table 16: Benefit Cost Analysis Results, Millions of 2016 Dollars 24
Table 17: Benefits by Long-Term Outcome, Millions of 2016 Dollars 25
Table 18: Benefit Cost Analysis Sensitivity Analysis, Millions of 2016 Dollars 25

1 INTRODUCTION

A benefit-cost analysis (BCA) was conducted for the Kansas City: Connecting Our Riverfront for Everyone (KC●CORE) for submission to the U.S. Department of Transportation (U.S. DOT) as a requirement of a discretionary grant application for the TIGER 2017 program. The following section describes the BCA framework, evaluation metrics, and report contents.

1.1 BCA FRAMEWORK

A BCA is an evaluation framework to assess the economic advantages (benefits) and disadvantages (costs) of an investment alternative. Benefits and costs are broadly defined and are quantified in monetary terms to the extent possible. The overall goal of a BCA is to assess whether the expected benefits of a project justify the costs from a national perspective. A BCA framework attempts to capture the net welfare change created by a project, including cost savings and increases in welfare (benefits), as well as reduction in benefits where costs can be identified (e.g., project capital costs), and welfare reductions where some groups are expected to be made worse off as an outcome of the proposed project.

The BCA framework involves defining a Base Case or "No Build" Case, which is compared to the "Build" Case, where the grant request is awarded and the project is built as proposed. The BCA assesses the incremental difference between the Base Case and the Build Case, which represents the net change in welfare. BCAs are forward-looking exercises which seek to assess the incremental change in welfare over a project life-cycle. The importance of future welfare changes are determined through discounting, which is meant to reflect both the opportunity cost of capital as well as the societal preference for the present.

The analysis was conducted in accordance with the benefit-cost methodology as recommended by the U.S. DOT in the 2017 TIGER Benefit-Cost Analysis Guidance.[1] This methodology includes the following analytical assumptions:

- Assessing benefits with respect to each of the five long-term outcomes defined by the U.S. DOT;
- Defining existing and future conditions under a No Build base case as well as under the Build Case;
- Estimating benefits and costs during project construction and operation, including at least 20 years of operations beyond the Project completion when benefits accrue;
- Using U.S. DOT recommended monetized values for reduced fatalities, injuries, property damage, travel time savings, and emissions, while relying on best practices for monetization of other benefits;
- Presenting dollar values in real 2016 dollars. In instances where cost estimates and benefits valuations are expressed in historical dollar years, using an appropriate Consumer Price Index (CPI) to adjust the values; and
- Discounting future benefits and costs with real discount rates of 7 percent and 3 percent (sensitivity analysis) consistent with U.S. DOT guidance.

[1] Federal Highway Administration. (2000). *Addendum to the 1997 Federal Highway Cost Allocation Study Final Report.* https://www.fhwa.dot.gov/policy/hcas/addendum.cfm

1.2 PRISM

This benefit cost analysis was done using PRISM™, a benefit cost analysis tool that uses a methodology consistent with the most recent guidelines developed by U.S. DOT. The tool determined benefits according to the following five categories: Quality of Life; Economic Competitiveness; Safety; State of Good Repair; and Environmental Sustainability.

1.3 REPORT CONTENTS

The contents of the report are organized as follows:

- Section 1 includes the Introduction.
- Section 2 of this report provides a project overview and general BCA assumptions
- Section 2.4 describes the project costs including initial investment costs, and operating, maintenance, and other life-cycle costs.
- Section 3 describes the demand projections made for the area surrounding the proposed Riverfront streetcar stop.
- Section 4 describes the project benefits, including a summary of benefits with respect to the five long-term outcome criteria set forth by the DOT, and provides details on the factors and assumptions used to derive benefits for each benefit type
- Section 5 summarizes the results of the benefit-cost analysis and sensitivity analysis to assess the impacts of changes in key estimating assumptions.

2 PROJECT OVERVIEW

2.1 DESCRIPTION

The Kansas City Streetcar (KC Streetcar) began operation in May 2016. The existing streetcar spans a 2.2-mile route between the River Market and Union Station in downtown Kansas City, MO. This route facilitates access to Kansas City's central business district along Main Street while connecting users to other modes of transportation including the regional RideKC Bus system. The existing service has been very successful, with the streetcar celebrating its 2 millionth passenger before the end of its first year of service – this represents 74% higher ridership than the original opening-year estimate of 1.15 million trips. The total project cost was $102.5 million, of which $20 million was funded via a TIGER grant in 2013.

The development and implementation of the initial 2.2-mile route was overseen by three partners: the Kansas City Streetcar Authority (KCSA), Kansas City Area Transportation Authority (KCATA), and the City of Kansas City, Missouri (KCMO). In 2016, the project partners along with Port KC began to investigate the feasibility of extending the streetcar to the Riverfront and changing multi-modal connections and paths in the study area. In light of the proposed mixed-use development of 12 Riverfront parcels with completion dates ranging from 2018 through to 2029, this project and proposed streetcar extension is intended to provide connectivity between the Riverfront and the downtown, stimulate economic activity at the Riverfront, and provide a non-vehicle travel option to access the "string" of downtown districts, as well as address parking demand and growing congestion.

Six alignment options were previously considered for the service extension on the basis of structural requirements, public perception and input, operational needs and limitations, cost estimates (operational and capital), as well as funding and financing. The preferred alternative involves construction of a double-track beginning at the intersection of 3rd Street and Grand Avenue which traverses north up Grand Avenue bridge, under the Heart of America Bridge, to River Front Road. Under this alternative, a central station stop will be constructed near the midpoint of the Riverfront development.

This project would facilitate a reduction in Passenger Hours Travelled (PHTs) and Vehicle Miles Travelled (VMTs) for existing traffic as well as transportation demand from the proposed Riverfront development. The streetcar would also encourage increased travel between the Riverfront development and downtown Kansas City for work and recreational purposes. In addition to the streetcar extension, a pedestrian and bicycle path along the Grand Avenue Bridge has been proposed to improve access to the Riverfront. This facility would encourage active transportation, reducing local vehicular VMTs, while also promoting health and recreational benefits, and improve safety for existing active transportation users.

2.2 GENERAL ASSUMPTIONS

2.2.1 *BASIS OF ECONOMIC BENEFITS*

The primary drivers of quantifiable project benefits for the BCA are VHT savings and VMT savings. By eliminating an average of six million miles of vehicular travel per year, significant cost savings from reduced fuel consumption, reduced vehicle maintenance, oil imports, and emissions will be realized. Eliminating up to 22,000 hours of travel per year will translate to substantial passenger time savings, which can be monetized. Additionally, the pedestrian and bicycle path allows for quantifiable sustainability-mobility as well as health benefits.

This project would also be expected to generate significant benefits in terms of community development (land value uplift from increased investment in Riverfront development) and safety (reduced vehicle crashes due to reduced VMTs as users switch from auto to transit, and improved pedestrian and cycling safety due to the new pedestrian and cycling facility). Given the challenge of accurately quantifying these benefits, this BCA discusses community development and safety benefits qualitatively, noting that the true economic benefit (and Benefit-Cost Ratio) is likely higher than the value presented herein.

2.2.2 *DISCOUNTING AND REAL DOLLAR VALUATIONS*

Dollar figures in this analysis are expressed in constant 2016 dollars as costs and unit values for benefits, such as diesel fuel prices, are not available for 2017. While expressed in 2016 dollars, all Present Value cost and benefit streams are discounted to 2016, consistent with TIGER program guidance.

The real discount rate used for this analysis is 7.0%, consistent with U.S. DOT guidance for TIGER grants[2] and OMB Circular A-4.[3] An alternate BCA model run was also conducted using a 3.0% discount rate applicable to all benefits and costs. The lower discount rate may be justified on two counts:

[2] U.S. Department of Transportation. Benefit-Cost Analysis Guidance for TIGER Applicants. 2016.
[3]TIGER 2015 NOFA: Benefit-Cost Analysis Guidance, Updated March 27, 2015; http://www.dot.gov/tiger/guidance

1. To the extent that project funding reduces future consumption, rather than investment, a lower discount rate may be merited to reflect the lower opportunity cost associated with foregone consumption; and

2. To reflect a more nuanced social rate of time preference for future versus short-term economic enhancements. However, 7.0 % is the primary rate used in this BCA analysis.

2.2.3 *EVALUATION PERIOD*

The Streetcar Riverfront Extension and Multi-Modal Feasibility Study outlines the commencement of engineering work in 2017, construction in 2019, and operation in June of 2021. The complete analysis period (i.e., the period of discounting) begins with the first expenditures in 2017 and continues through 2046, for a total of 30 years. This covers four years of capital outlays and 26.6 years of operation. Capital expenditures during this time were outlined in the cash flow statements provided by Burns and McDonnell.

All benefits and costs are assumed to occur at the end of each year, and benefits begin in the month (June) immediately following the final construction period, in 2021.

2.2.4 *RIDERSHIP ESTIMATES AND PROJECTION SOURCES*

Kansas City Streetcar extension ridership data were developed using surveys and passenger counts for the existing streetcar line, provided by Burns and McDonnell. Projections are based on current ridership for the existing line along Main Street, induced ridership from the proposed development (based on the extent of proposed development in each of the No-Build and Build cases), and conservative growth rates during operational years. Capacity constraints were examined in Section 3.2 to confirm maximum line capacity (with existing vehicles) would not be exceeded within the study period under the analysis's passenger growth assumptions.

The methodology for estimating travel time savings and VMT savings is described in Section 3. Annualization Factor Determination

Induced daily ridership estimates were provided as inputs to the model based on the number of housing units to be included in the proposed developments on the Riverfront parcels. Induced daily ridership forecasts were annualized using an annualization factor of 442.7, derived as follows:

- $(52\ weeks\ per\ year) \times (5\ weekdays\ per\ week) - (6\ statutory\ holidays\ per\ year) = 254\ days$
- The current streetcar ridership indicates a higher ridership on the weekends in comparison to the weekdays. This is due to attractions in downtown Kansas City that have proved to keep ridership high; these include areas such as the Power and Light district, the City Market farmers market that operates all year around, as well as the Sprint Center. Therefore, the remaining days in the year $(365 - 254 = 111)$ are assumed to generate 1.7 times (as provided by Burns and McDonnell) the ridership of a weekday, and are thus counted as $(111 \times 1.7 = 188.7\ weekdays)$

The total annualization factor was thus calculated as $(254 + 188.7 = 442.7)$ x average weekday daily ridership projections.

2.2.5 *BENEFIT-COST EVALUATION MEASURES*

The benefit-cost analysis converts potential gains (benefits) and losses (costs) from the Project into monetary units and compares them. The following two common benefit-cost evaluation measures are included in this BCA.

- **Net Present Value (NPV)**: NPV compares the net benefits (benefits minus costs) after being discounted to present values using the real discount rate assumption. The NPV provides a perspective on the overall dollar magnitude of cash flows over time in today's dollar terms.
- **Benefit Cost (B/C) Ratio**: The evaluation also estimates the B/C ratio. The present value of incremental benefits is divided by the present value of incremental costs to yield the B/C ratio. The B/C ratio expresses the relation of discounted benefits to discounted costs as a measure of the extent to which a project's benefits either exceed or fall short of their associated costs.

2.3 NO BUILD CASE AND BUILD CASE

The No Build case defined for the streetcar Riverfront extension does not include construction of the bicycle and pedestrian facility on the Grand Avenue Bridge, nor does it include extension of the existing streetcar service to the Riverfront. However, the No Build case assumes a small degree of the proposed Riverfront development will continue regardless of whether the streetcar extension occurs. The Berkley Riverfront Development Master Planned Development (MPD) outlines two density scenarios contingent upon the construction of the streetcar extension. The MPD low-density development scenario has been used for the purpose of the No Build Case. This case assumes annualized ridership growth of 2.6% starting in June 2021 to account for streetcar trips generated from the low-density development scenario. Calculation of the annualized growth rate is discussed in Section 3.

The Build Case defined for this analysis follows the MPD high-density development, which assumes less required parking than is proposed in the No Build Case and thus facilitates a larger residential square footage. The induced ridership forecast by Burns and McDonnell was projected based on the projected build-out year for each parcel in close proximity to the proposed Riverfront streetcar station. A linear increase in travel demand was assumed between build-out years, with a conservative estimate of annualized 2.6% ridership growth after 2029 (the date when the final parcel is expected to finish development).

2.4 PROJECT COSTS

2.4.1 *CAPITAL COSTS*

The following capital costs were estimated in the BCA (spreadsheet link):

- **Guideway and Track Elements:** includes at-grade upgrades, aerial structure, ties and ballast, embedded track, and special track features such as track switches. This work stretches from 200 feet south of 3rd and Grand Boulevard to the station stop on the Riverfront.
- **Stations, Stops, Terminals, Intermodal:** includes construction of a streetcar stop at the midpoint of the Riverfront development and construction of a multi-modal transit hub at the northeast corner of 3rd St. and Grand Blvd., replacing the existing streetcar stop at 3rd St. and Walnut St.
- **Support Facilities:** includes a new yard track for additional storage, as well as administrative buildings.

- **Site Work and Special Conditions:** includes demolition and earthworks, utility allowances, site work for the right-of-way, signs and street lighting over the roads and bridges, as well as temporary facilities for the contractor.
- **Systems:** includes traffic control for traffic signals and streetcar signals, traction power substations and distribution, and communications.
- **Vehicles:** the capital cost estimate includes the addition of one vehicle and spare parts, as required to meet headway and capacity requirements.
- **Professional Services:** assumed to be 25% of the capital costs (excluding vehicle costs). Includes design costs, construction management, and owner project administration.
- **Contingency:** 15% of estimated capital costs.

Table 1: Project Schedule and Costs, Millions of 2016 Dollars

Variable	Unit	Value (@ 7% discount rate)	Value (@ 3% discount rate)
Construction Start	date	2017	2017
Construction End	date	May 2021	May 2021
Construction Duration	years	4	4
Project Opening	date	June 2021	June 2021
Capital Costs	$ M	$25.3	$28.9
Operating and Maintenance Costs	$ M	$7.1	$12.6

Source: Riverfront Cash Flow, Burns and McDonnell

2.4.2 *OPERATIONS AND MAINTENANCE COSTS*

Operations and maintenance (O&M) costs were estimated based on the existing streetcar operating cost of $122.50 per operating hour. The proposed extension requires an additional 6,600 revenue hours per year to operate and one additional vehicle. This translates to an increase of approximately 50,000 revenue miles and $808,500 in expenditures annually. The existing streetcar will require annual O&M expenditures which are not expected to change under the Build Scenario; as such, only the cost to operate and maintain the streetcar extension and additional vehicle have been considered. O&M expenditures are shown in Table 1.

3 DEMAND PROJECTIONS AND ASSOCIATED SAVINGS

Build Case streetcar ridership projections were used to estimate savings of Passenger Hours Travelled (PHTs) and Vehicle Miles Travelled (VMTs), upon which quantification of benefits was based. Ridership projections were completed by Burns & McDonnell, taking into account existing ridership and projected numbers of residential units to be constructed on the land parcels adjacent to the proposed Riverfront streetcar station.

Given that ridership projections were based on the number of proposed residential units adjacent to the proposed Riverfront streetcar stop, this estimate is likely conservative in that the proposed parcel developments – which are intended to be mixed-use – will likely attract streetcar trips from individuals not living in the proposed developments; however, these trips have not been quantified for the purposes of this BCA.

3.1.1 *INDUCED STREETCAR TRIPS*

Travel Distance Estimates

Half of induced trips by residents in the proposed Riverfront developments were assumed to *board* at the proposed Riverfront streetcar station, while the other half were assumed to *alight* at the proposed station. Operating within this constraint, induced trips were assumed to follow existing streetcar user travel patterns: for southbound trips leaving the proposed station, induced trips were assumed to alight according to existing southbound stop-by-stop alighting distributions. Similarly, induced northbound trips heading to the proposed station were assumed to board according to existing northbound stop-by-stop boarding patterns. Using this logic, average in-vehicle passenger trip distances (and travel times) were estimated.

Walk distances between the proposed developments and the proposed streetcar station were calculated as an average (weighted by development gross area) of the distance between each designated land parcel and the location of the proposed stop. Walk distances at the other end of the journey for induced streetcar passenger trips were assumed to be an average of 1/8th of a mile, or 660 feet.

Residents who move into the proposed Riverfront developments were assumed to relocate from other parts of Kansas City, MO. However, lacking data on which communities these residents are expected to relocate from, relocated residents were assumed to be 'average' travellers according to census statistics. Average values for Kansas City, MO commuter travel time and modal split were used thus in calculating VHT and PHT savings.

PHT Savings Estimates

The average commuter trip in Kansas City takes 22 minutes, according to the US Census Bureau's 2016 American Community Survey.[4] PHT savings were therefore estimated based on a comparison of average travel time for induced trips on the streetcar versus the average commuter trip time of 22 minutes. Average travel time for induced streetcar trips was calculated as a function of average travel distance, as described above; streetcar travel speed as outlined by the Streetcar Riverfront Extension Feasibility Study by Burns & McDonnell; passenger wait time, assumed to be 3 minutes (25% of streetcar headway) on the assumption that passengers time their arrival with streetcar schedules; and a walk speed of 3.0 mph. Because average trip durations for non-commuting purposes were not available, the average commuter trip was used as a proxy for an average trip of any kind in Kansas City, MO. Daily estimates were annualized using the annualization factor described in Section 0.

VMT Savings Estimates

As described above, the average commuter trip in Kansas City, MO takes 22 minutes. The US Census Bureau's 2016 American Community Survey[5] states that commuters who do not work from home have an auto mode share of 95% in Kansas City. Assuming an average travel speed of 26.25 mph (75% of the typical posted speed limit of 35mph), VMT savings were calculated as a function of the number of reduced auto trips (assumed to be 95% of induced streetcar trips); average travel time and speed; and average vehicle occupancy for Kansas City, MO.[6] Daily estimates were annualized using the annualization factor described in Section 1.1.5. Additionally, a

---

[4] White House Office of Management and Budget, Circular A-94, *Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs* (October 29, 1992). (http://www.whitehouse.gov/omb/circulars_a094).

[5] https://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=ACS_16_1YR_S0801&prodType=table

[6] https://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=ACS_16_1YR_S0801&prodType=table

reduction was applied using the percent of users using the streetcar for recreation purposes (75.92%) as well as an assumption where non-commuting/recreation trips earn 75% of VMT savings of commuting trips.

Table 2 summarizes the assumptions and inputs used for these calculations.

Table 2: PHT and VMT Assumptions and Inputs (Induced Trips)

Variable	Unit	Value	Source/Calculation
Ridership in 2016 (first 241 service days)	Trips	1,399,153	KC Streetcar Passenger Counts based on 241 service days (provided by Burns & McDonnell)
Ridership in 2017 (first 241 service days)	Trips	1,436,820	KC Streetcar Passenger Counts based on 241 service days (provided by Burns & McDonnell)
No Build Ridership Growth Rate (after 2022)	%	2.62%	Calculated based on the ridership in 2016 and 2017. This growth rate is used as the ridership
Base Daily Ridership	Trips per day	5,830	Streetcar Riverfront Extension and Multi-Modal Feasibility Study
Build Case Incremental Ridership (2022 to 2029)	Trips per day	410 to 4,557	The ridership data was provided for years 2022 through 2029 by Burns & McDonnell. Growth was assumed to be linear between years.
Build Case Ridership Growth (after 2029)	%	2.62%	Equal to No Build growth rate
Mode Splits	% Transit	2.8%	2016 American Community Survey, adjusted to account only for people that do not work from home.[5]
	% Bicycle	0.2%	
	% Walking	1.8%	
	% Auto	95.2%	
Average Walk Speed	Miles/hour	3.00	Based on US DOT Federal Highway Administration specified range of 4 to 8 feet/second.
Average Auto Speed	Miles/hour	26.25	Assumed to be ¾ of typical posted speed limit (35mph)
Average Bike Speed	Miles/hour	10.50	The average bicycle speed was determined from the US DOT Federal Highway Administration.
Average Work Commute	Minutes	22	2016 American Community Survey.
Average Vehicle Occupancy	Pssngrs/ vehicle	1.05	2016 American Community Survey.
Percent of Existing Users Travelling for Recreation	%	75.92	Based on the trip purpose survey conducted by KC Streetcar, it was determined that 75.92% of trips for the existing streetcar were for recreational purposes.
Reduction in VMT for non-commuting trips	%	75	A conservative assumption was used to estimate the reduction of VMTs for non-commuting versus commuting trips. This indicates that non-commuting or recreational trips are assumed to earn 75% of the VMTs savings of commuting trips.

Based on the KC Streetcar Passenger Count from the first day of operation to August 2017, the distribution of passengers boarding and alighting at the various stops is as follows:

Table 3: Boarding and Alighting Distribution

Stop	% Alighting	% Boarding
River Market North on 3rd Street at Grand WB	17.0%	
River Market West on Delaware at 4th Street SB	9.9%	
North Loop on Main at 7th Street SB	1.9%	
Library on Main at 9th Street SB	7.6%	
Metro Center on Main at 12th Street SB	14.9%	
Power and Light on Main at 14th Street SB	12.2%	
Kauffman Center on Main at 16th Street SB	8.2%	
Crossroads on Main at 19th Street SB	16.5%	
Union Station on Main at Pershing SB	11.8%	7.3%
Crossroads on Main at 19th Street NB		44.9%
Kauffman Center on Main at 16th Street NB		7.2%
Power and Light on Main at 14th Street NB		8.1%
Metro Center on Main at 12th Street NS		8.9%
Library on Main at 9th Street NB		4.2%
North Loop on Main at 7th Street NB		1.4%
City Market on Walnut at 5th Street EB		18.0%

3.1.2 *EXISTING STREETCAR TRIPS*

Existing streetcar users are assumed to experience no VMT savings or penalties under the No Build or Build cases. In reality, there may be a small VMT savings for existing streetcar users in the Build Case as there may be a small number of users who currently drive (or are driven) between the proposed Riverfront streetcar station and the existing streetcar line who may cease to drive under the Build Case; however, the benefits associated with this are expected to be small and therefore have not been quantified.

PHT savings are anticipated for users who currently access the Riverfront using the existing streetcar line. These users are assumed to walk from the existing terminal station to the Riverfront, approximately 0.8 miles away. The number of current users assumed to be accessing the Riverfront by foot is estimated as 5% of existing users who travel for recreational purposes to or from the northern terminal stop of the streetcar line.

Table 4: PHT and VMT Assumptions and Inputs (Existing Trips)

Variable	Unit	Value	Source/Calculation
Base Daily Ridership	Trips per day	5,830	Streetcar Riverfront Extension and Multi-Modal Feasibility Study
Users Travelling for Recreation	%	75.9%	This value was determined based on KC Streetcar survey results provided by Burns & McDonnell. It was assumed that new users will follow the same travel patterns as existing.
Users Walking from River Market to Riverfront Development for Recreational Purposes	%	5%	A conservative estimate was used to model the number of users travelling for recreational purposes through the extension. As indicated by Burns and McDonnell, this estimate was assumed to be 5% as parking is limited and passengers likely would not have access to a vehicle after alighting.
Average Walk Speed	Miles/hour	3.00	Based on US DOT Federal Highway Administration specified range of 4 to 8 feet/second.
Walk Distance	Miles	0.8	Distance between existing northern terminal stop and proposed Riverfront streetcar stop.

3.1.3 *TOTAL PHT AND VMT SAVINGS*

Using the assumptions outlined in Table 2 and Table 4, VMT and PHT savings were calculated for both the Build and No Build cases. The results are presented in Table 5 and were used as inputs to quantify the project benefits.

Table 5: Total No Build and Build PHT and VMT Savings

Variable	First Full Year of Benefits (2022)		Final Year of Analysis	
	No Build	Build	No Build	Build
Reduced Car Trips	50,449 trips	497,095 trips	93,881 trips	2,300,208 trips
Reduced Vehicle Miles Travelled	485,569 hours	4,784,543 hours	903,602 hours	22,139,506 hours
Reduced Travel Time	1,045 hours	14,472 hours	1,945 hours	51,820 hours
Reduced Passenger Hours Travelled – Auto	995 hours	9,799 hours	1,851 hours	45,345 hours
Reduced Passenger Hours Travelled – Bus	30 hours	4,467 hours	55 hours	5,525 hours
Reduced Passenger Hours Travelled – Bicycle + Walk	21 hours	205 hours	39 hours	950 hours

Source: WSP

3.2 STREETCAR CAPACITY CONSTRAINTS

Calculations were performed to confirm that the capacity of the streetcar line will not be exceeded as a result of project annual ridership growth under the No Build and Build cases. Though the Build case will result in a longer travel distance and thus a slower round-trip travel time for streetcar vehicles, the purchase of an additional vehicle is intended to maintain the existing headway, and thus the existing capacity, of the streetcar line. Because higher ridership is projected under the Build case, streetcar line capacity was compared to projected Build case ridership

in the last year of project operation to confirm that existing capacity will be sufficient for the duration of the project.

Streetcar capacity was calculated as follows:

- Given headway of 12 minutes:
  - $Frequency = \left(\frac{60\ min/hour}{12\ min}\right) = 5\ vehicles/hour$
- Given per-vehicle capacity of 150 passengers
  - $Total\ line\ capacity = (150\ passengers) \times (5\ vehicle/hour) = 750\ passengers/hour$
- Given Approx. 18 operating hours per day during weekdays, when peak ridership is anticipated
  - $Daily\ capacity = (18\ hours) \times (750\ passengers) = 13{,}500\ passengers/day$

Maximum anticipated daily ridership was estimated to be 10,241 (Build case in 2046), substantially lower than the capacity of the streetcar line. Thus, ridership growth is not expected to be limited by the capacity of the streetcar line.

4 PROJECT BENEFITS

The KC●CORE Project would allow for a number of economic, environmental, quality of life, and state-of-good-repair benefits for Kansas City.

Quality of Life

- The project will enhance connectivity to the Riverfront development. The streetcar extension will allow users from the development to access 28 existing bus lines, the Downtown Transit Center, Amtrak's national network, Johnson County Transit, and future potential commuter rail service.
- The project will introduce bicycle and pedestrian facilities from Main Street across the Grand Avenue Bridge, connecting to the River Front Heritage Trail to improve walkability and pedestrian activity.
- The streetcar extension has the potential to reach the Isle of Capri land east of the I-29/35.
- By reducing auto VMTs, this project will benefit surrounding communities by reducing ambient noise.

Economic Competitiveness

- The construction of the streetcar extension would enable not only a denser Riverfront development, therefore increasing the value of the land which is currently undeveloped, but will allow future residents of this development to access downtown Kansas City.
- The project will enable direct transportation access to the central business district's employment centers for new users as well as direct transportation for downtown residents to the Riverfront.
- The anticipated reduction of VMTs will translate to fuel savings, reduced oil imports, and reduced vehicle operating costs.
- The streetcar extension supports and attracts tourism to the Riverfront.

- Increased fare revenue resulting from increased ridership was treated as a transfer and therefore assumed to have no impact on net project benefit.
- The project also supports a reduction in parking spaces in downtown Kansas City. This has proven to be an increasing concern for the city as space is limited and congestion is increasing.

State-of-Good-Repair

- The anticipated reduction of VMTs will result in less wear and tear on existing road infrastructure, lowering the burden on tax payers.
- The streetcar extension is expected to have a useful service life of 50 years, or 24 years beyond the evaluation period. The investment will therefore have a residual value at the end of the evaluation period as it will not have reached the end of its service life.

Environmental Sustainability

- The anticipated reduction of VMTs will translate to fuel savings, reduced road damage, reduced wear and tear for vehicles, as well as a reduction in emissions.
- The streetcar extension would reduce the need for parking in downtown Kansas City, which has already proven to be a concerning issue.
- The reduction in vehicles also lowers the amount of noise pollution along the streetcar line.

All of the above benefits are monetizable and would begin to accrue immediately upon completion of the streetcar extension in 2021, continuing to accrue throughout the lifespan (or evaluation period) of the upgraded facility.

Community Development and Safety

In addition to the above benefits, this project would also be expected to generate significant benefits in terms of community development and safety. However, given the challenge of accurately quantifying these benefits, this analysis only considers these benefits qualitatively, noting that the true economic benefit (and Benefit-Cost Ratio) is likely higher than the value presented herein.

The existing streetcar line has contributed significantly to the revitalization of downtown Kansas City; extension of the streetcar line to the Riverfront is expected to support a similar transformation of the currently underused Riverfront property. Though situated in a prime location, limited access to the Riverfront has long suppressed development of the adjacent land parcels. Extending the streetcar line is anticipated to significantly increase land value and generate increased economic activity in the community. While preliminary quantitative estimates of land value uplift have been produced, land value uplift is typically considered a reflection of all other project benefits. To avoid double-counting benefits and avoid reliance on uncertain land value uplift calculations, this benefit is considered quantitatively.

Both the extension of the streetcar line and addition of a pedestrian and cycling facility on the Grand Avenue bridge are expected to bring safety benefits to the community. Reduced VMTs (as described in Section 3.1.1), as well as the reduction in bikers and pedestrians crossing at-grade sections, are expected to result in fewer crashes. Providing safer walking and pedestrian facilities will, all other things being equal, reduce crashes associated with pedestrian and cyclists, and likely contribute to a marginal mode switch to walking and cycling in the community.

Table 6 below summarizes and categories each of the benefits described in this section.

Table 6: Project Benefits by Long-Term Outcome Category

Long-Term Outcome	Benefit (Disbenefit) Category	Description	Monetized @ 7% Discount Rate	Monetized @ 3% Discount Rate
Quality of Life / Livability	Health Benefits	Reduced healthcare costs associated with increased physical activity will result from improved cycling facilities.	$100,000	$190,000
	Commuter Mobility Benefits	Commuters will experience mobility benefits associated with improved cycling facilities.	$400,000	$775,000
	Recreational Benefits	Recreation benefits will result from improved cycling facilities.	$5,000	$9,000
	Reduced Noise	Reduced VMTs will lead to a reduction in noise pollution.	$120,000	$245,000
	Community Development	Development spurred by extension of the streetcar line will increase livability, services, and land values	Qualitative benefit	
Economic Competitiveness	Travel Time Savings	Construction of the streetcar extension will allow the additional users from the Riverfront development to access downtown Kansas City for recreational and work commutes, reducing PHTs for all road users.	$4,260,000	$8,630,000
	Vehicle Operating Costs	Reduced VMTs associated with the Riverfront development and the streetcar extension, as well as reduced passenger vehicle VMTs due to increased cycling mobility, will result in less money spent on vehicle-related O&M expenses.	$30,330,000	$61,330,000
	Fuel Savings	Reduced VMTs will result in less money spent on fuel.	$9,470,000	$18,920,000
Safety	Reduced Incidents	Reduced VMTs due to modal switch from auto to transit, and due to provision of dedicated pedestrian and cycling facility.	Qualitative benefit	
State of Good Repair	Reduced Road Damage	Reduced VMTs associated commuters would result in less wear and tear on local roads, reducing maintenance costs.	$120,000	$245,000
	Residual Value	The streetcar extension is expected to have a useful service life of 50 years, or 24 years beyond the evaluation period.	$2,020,000	$6,340,000
Environmental Sustainability	Reduced Emissions	Decreased VMTs will lead to a decrease in total emissions from the vehicles of existing users and new users from the Riverfront development.	$3,160,000	$3,315,000

4.1 QUALITY OF LIFE / LIVABILITY

This project will create quality of life / livability benefits which include improved health, improved mobility, increased recreation, and reduced noise levels. The first three benefits are an outcome of the increase in cycling activity that this project facilitates, and will be realized by Kansas City residents, most notably those living along the streetcar line in downtown KC and those living at the new Riverfront development. Current streetcar passengers will also realize these savings when travelling for recreational purposes to the scenic Riverfront and River Front Heritage Trail. The fourth benefit (noise reduction) is an outcome of reduced VMTs.

Health benefits are monetized based on the reduced healthcare costs associated with an increase in physical activity. Mobility benefits are monetized based on the average commuter's value of time combined with the extent to which cycling becomes a more desirable commuting method. Recreation benefits are monetized based on the number of cyclists induced by this Project, combined with the average value of time for recreation. Noise reduction benefits are monetized based on the annual reduction in VMTs and noise monetization factors, estimated by the Federal Highway Administration.[7] The following table outlines the benefits associated with quality of life.

Table 7: Quality of Life / Livability Estimation of Benefits

Benefit	First Full Year of Benefits (2022)			Project Lifecycle		
	Undiscounted	Discounted (7%)	Discounted (3%)	Undiscounted	Discounted (7%)	Discounted (3%)
Health Benefits	$12,000	$7,700	$10,000	$319,000	$103,000	$189,000
Commuter Mobility Benefits	$42,000	$28,000	$35,000	$1,332,000	$414,000	$777,000
Recreational Benefits	$500	$300	$400	$14,000	$5,000	$9,000
Reduced Noise	$3,200	$2,200	$4,500	$443,000	$121,000	$245,000

Table 8: Quality of Life / Livability Assumptions and Sources

Variable	Unit	Value	Source
Population Density in Specified Area	Persons / sq.mi.	1,460	US Census Bureau 2016
Population Data Basis	year	2016	US Census Bureau 2016
Annual Population Growth	%	0.7%	US Census Bureau 2016
Length of the Bicycle Facility	mile	0.25[8]	Length of Grand Blvd bridge
Percentage of Adult Residents in Area	%	75.8%	US Census Bureau 2016

[7] Federal Highway Administration. (2000). *Addendum to the 1997 Federal Highway Cost Allocation Study Final Report.* https://www.fhwa.dot.gov/policy/hcas/addendum.cfm

[8] The true length of additional bicycle facilities will be only 0.25 miles (i.e., the length of the bridge). However, because the cycling facilities on the bridge would serve to link up two otherwise disconnected locations, with a total path length of approximately 59 miles, the improvement to the local facilities was estimated as being equivalent to an increase of 10% of the length of the total local network.

Percentage of Commuters	%	50%	NCHRP 552: Guidelines for Analysis of Investments in Bicycle Facilities[9]
Percentage of Bicycle Commute Share	%	0.6%	US Census Bureau 2016
Percentage of Children who Ride a Bike on a Given Day	%	5.0%	National Household Transportation Survey 2001[10]
Extra minutes per trip	min	20.38	NCHRP 552: Guidelines for Analysis of Investments in Bicycle Facilities[7]
Average noise savings per auto VMT	2015 $ / VMT	0.001	Federal Highway Administration[11]

4.2 ECONOMIC COMPETITIVENESS

This project would contribute to increasing the economic competitiveness of the Nation through improvements in the mobility of people in the study area. Three types of societal benefits are measured in the assessment of economic competitiveness: travel time savings, vehicle operating savings, and fuel savings that will be realized by users of the streetcar extension in the Riverfront development.

Table 9: Economic Competitiveness Estimation of Benefits

Benefit	First Full Year of Benefits (2022)			Project Lifecycle		
	Undiscounted	Discounted (7%)	Discounted (3%)	Undiscounted	Discounted (7%)	Discounted (3%)
Travel Time Savings	$204,000	$136,000	$170,828	$15,652,000	$4,256,000	$8,635,000
Vehicle Operating Costs	$1,348,000	$898,000	$1,129,000	$110,694,000	$30,330,000	$61,330,000
Fuel Savings	$403,000	$321,000	$403,000	$33,882,000	$9,467,000	$18,920,000

4.2.1 *TRAVEL TIME SAVINGS*

Travel time savings includes in-vehicle travel time savings for auto drivers and passengers. Travel time is considered a cost to users, and its value depends on the disutility that travelers attribute to time spent traveling. A reduction in travel time translates into more time available for work, leisure, or other activities. The assumptions used in the estimation of travel time savings are presented in the following table.

Table 10: Travel Time Savings Assumptions and Sources

Variable	Unit	Value	Source
Average Vehicle Occupancy – Passenger Vehicles	Passengers /vehicle	1.05	United States Census Bureau 2016 (for Kansas City, MO)

[9] National Cooperative Highway Research Program. (2006). Guidelines for Analysis of Investments in Bicycle Facilities. http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_552.pdf

[10] Federal Highway Administration. (2005). National Household Travel Survey 2001. http://nhts.ornl.gov/download.shtml

[11] Federal Highway Administration. (2000). *Addendum to the 1997 Federal Highway Cost Allocation Study Final Report.* https://www.fhwa.dot.gov/policy/hcas/addendum.cfm

Intercity Personal Value of Travel Time	2016$ per person-hour	19.00	USDOT Value of Travel Time Guidance 2016
Intercity Business Value of Travel Time	2016$ per person-hour	25.40	USDOT Value of Travel Time Guidance 2016
Value of Time Real Growth Rate	%/year	1.2%	USDOT 2014

4.2.2 *OPERATING COST SAVINGS*

Vehicle operating cost savings includes the cost of fuel, as well as maintenance and repair, replacement of tires, and the depreciation of the vehicle over time. Consumption rates per vehicle mile travelled (VMT) are used to calculate the vehicle operating cost savings. Estimates of VMT and unit costs for each component of vehicle operating cost are applied to the consumption rates to calculate the total vehicle operating cost. The assumptions used in the estimation of vehicle operating costs are presented in the following table.

Table 11: Operating Cost Savings Assumptions and Sources

Variable	Unit	Value	Source
VMT Savings: Auto (2022)	2022 VMT	4,299,000	Calculation (see Section 3.1.3)
VMT Savings: Auto (2029)	2029 VMT	13,678,000	Calculation (see Section 3.1.3)
Auto Maintenance & Repair	2016$	0.053	AAA "Your Driving Costs" 2016
Auto – Tires	2016$	0.10	AAA "Your Driving Costs" 2016
Auto - Depreciation	2016$	0.251	AAA "Your Driving Costs" 2016

4.3 SAFETY

The safety benefits assessed in this analysis include a reduction in fatalities and injuries, as well as a reduction in other property damage crash costs resulting directly from the project. Safety benefits for this project have been acknowledged qualitatively, however, not assessed quantitatively, due to the difficulty of estimating where VMT reductions will occur throughout the city. Safety benefits are anticipated for a number of reasons:

- A reduction in journeys is expected to lead to a commensurate reduction in the number of crashes
- The focus on multi-modal connectivity places an emphasis on:
    - The project will upgrade sidewalks to accommodate designed user-loads and adhere to Americans with Disabilities Act (ADA) requirements. The intersection upgrades will foster safe interactions with vehicles.
    - Lighting upgrades will be designed to provide better visibility for pedestrians and drivers.
    - Discontinuous sidewalks, interrupted bike paths, and obstructions will be removed to facilitate the multi-modal connections.

The above safety upgrades will benefit users that currently use the system and will choose to travel further to the scenic Riverfront for recreational purposes, future residents of the proposed Riverfront development, as well as tourism that is attracted to the area.

4.4 STATE OF GOOD REPAIR AND RESIDUAL VALUE

The state of good repair benefits assessed in this analysis include maintenance and repair savings, deferral of replacement cost savings, as well as reduced VMTs which leads to less road and pavement damage. The original streetcar as well as the extension are expected to continue functioning beyond the BCA evaluation period, and will thus leave a residual value to be captured in the final year of evaluation (2046) in the form of a deferral of replacement costs.

Given that the facilities anticipated to experience reduced VMTs are publicly owned and paid for, the benefits of reduced state-of-good-repair expenditures are expected to accrue to taxpayers (society) as a whole. However, the magnitude of state-of-good-repair benefits is expected to be minimal in comparison to monetized VMT and PHT savings.

Table 12: State of Good Repair Estimation of Benefits

Benefit	First Full Year of Benefits (2022)			Project Lifecycle		
	Undiscounted	Discounted (7%)	Discounted (3%)	Undiscounted	Discounted (7%)	Discounted (3%)
Reduced Road Damage	$5,400	$3,600	$5,400	$443,000	$121,000	$245,500
Residual Value	-	-	-	$15,380,000	$2,020,000	$6,340,000

The assumptions used in the estimation of state of good repair benefits are presented in the following table.

Table 13: State of Good Repair Benefits Assumptions and Sources

Variable	Unit	Value	Source
Auto Average Pavement Cost	2016$/VMT	0.001255	FHWA 2000

4.5 ENVIRONMENTAL SUSTAINABILITY

This project will create environmental and sustainability benefits relating to reduction in air pollution associated with decreased automobile travel as an increased number of commuters shift to using the streetcar. Five forms of emissions were identified, measured and monetized, including: nitrous oxide, particulate matter, sulfur dioxide, volatile organic compounds, and carbon dioxide.

A reduction in emissions was calculated based on rates quotes in the California Environmental Protection Agency's Air Resources Board EMFAC2011 Emissions Database together with vehicle miles travelled (VMT) savings. The total emissions reduction was then monetized using the social cost of carbon values referenced in the TIGER 2017 Guide.

Table 14: Environmental Sustainability Estimation of Benefits

Benefit	First Full Year of Benefits (2022)			Project Lifecycle		
	Undiscounted	Discounted (7%)	Discounted (3%)	Undiscounted	Discounted (7%)	Discounted (3%)

Reduced Emissions	$75,000	$61,000	$63,000	$6,016,000	$3,160,000	$3,320,000

The assumptions used in the estimation of environmental sustainability benefits are presented in the following table.

Table 15: Environmental Sustainability Benefits Assumptions and Sources

Variable	Unit	Value	Source
CO2 emissions	g / VMT	266.93	CARB EMFAC 2011
NOX emissions	g / VMT	0.09	CARB EMFAC 2011
SOX emissions	g / VMT	0.00	CARB EMFAC 2011
PM10 emissions	g / VMT	0.00	CARB EMFAC 2011
VOC emissions	g / VMT	0.21	CAL B/C, 2010

5 SUMMARY OF RESULTS

5.1 EVALUATION MEASURES

The benefit-cost analysis converts potential gains (benefits) and losses (costs) from the Project into monetary units and compares them. The following common benefit-cost evaluation measures are included in this BCA:

- Net Present Value (NPV): NPV compares the net benefits (benefits minus costs) after being discounted to present values using the real discount rate assumption. The NPV provides a perspective on the overall dollar magnitude of cash flows over time in today's dollar terms.
- Benefit Cost Ratio (BCR): The evaluation also estimates the benefit-cost ratio; the present value of incremental benefits is divided by the present value of incremental costs to yield the benefit-cost ratio. The BCR expresses the relation of discounted benefits to discounted costs as a measure of the extent to which a project's benefits either exceed or fall short of the costs.
- Internal Rate of Return (IRR): The IRR is the discount rate which makes the NPV from the Project equal to zero. In other words, it is the discount rate at which the Project breaks even. Generally, the greater the IRR, the more desirable the Project.
- Payback Period: The payback period refers to the period of time required to recover the funds expended on a Project. When calculating the payback period, the time value of money (discounting) is not taken into account.

5.2 BCA RESULTS

The table below presents the evaluation results for the project. Results are presented in undiscounted, discounted at 7 percent and discounted at 3 percent (sensitivity) as prescribed by the U.S. DOT. All benefits and costs were estimated in constant 2016 dollars over an evaluation period extending 26 years beyond system completion in 2021.

Table 16: Benefit Cost Analysis Results, Millions of 2016 Dollars

BCA Metric	Project Lifecycle

	Undiscounted	Discounted (7%)	Discounted (3%)
Total Benefits	$184.2	$50.0	$100.0
Total Costs	$52.7	$32.4	$41.5
Net Present Value (NPV)	$131.4	$17.6	$58.5
Benefit-Cost Ratio (BCR)	3.49	1.54	2.41
Internal Rate of Return (IRR)	10.7%		
Payback Period (Years)	9.9	19	15.5

The benefits over the project lifecycle are presented in the table below by U.S. DOT long-term outcome category.

Table 17: Benefits by Long-Term Outcome, Millions of 2016 Dollars

Long-Term Outcome	Project Lifecycle		
	Undiscounted	Discounted (7%)	Discounted (3%)
Quality of Life / Livability	$2.1	$0.6	$1.2
Economic Competitiveness	$160.2	$44.1	$88.9
Safety	(Qualitative)	(Qualitative)	(Qualitative)
State of Good Repair	$15.8	$2.1	$6.6
Environmental Sustainability	$6.0	$3.2	$3.3

5.3 SENSITIVITY TESTING

A sensitivity analysis is used to help identify which variables have the greatest impact on the BCA results. This analysis can be used to estimate how changes to key variables from their preferred value affect the final results and how sensitive the final results are to these changes. This allows for the assessment of the strength of the BCA, including whether the results reached using the preferred set of input variables are significantly different by reasonable departures from those values. The table below summarizes the key variables which have been tested for sensitivity and the results of this analysis.

Table 18: Benefit Cost Analysis Sensitivity Analysis, Millions of 2016 Dollars

Sensitivity Variable	Sensitivity Value	New BCR @ 7%	New NPV@ 7%
PHT Savings	Low Value (0.8)	1.52	$16.7
	High Value (1.2)	1.57	$18.5
VMT Savings	Low Value (0.8)	1.26	$8.5
	High Value (1.2)	1.83	$26.7
Capital Cost	Low Value (0.8)	1.82	$22.3
	High Value (1.2)	1.35	$13.0
O&M Cost	Low Value (0.8)	1.74	$21.2
	High Value (1.2)	1.64	$19.5